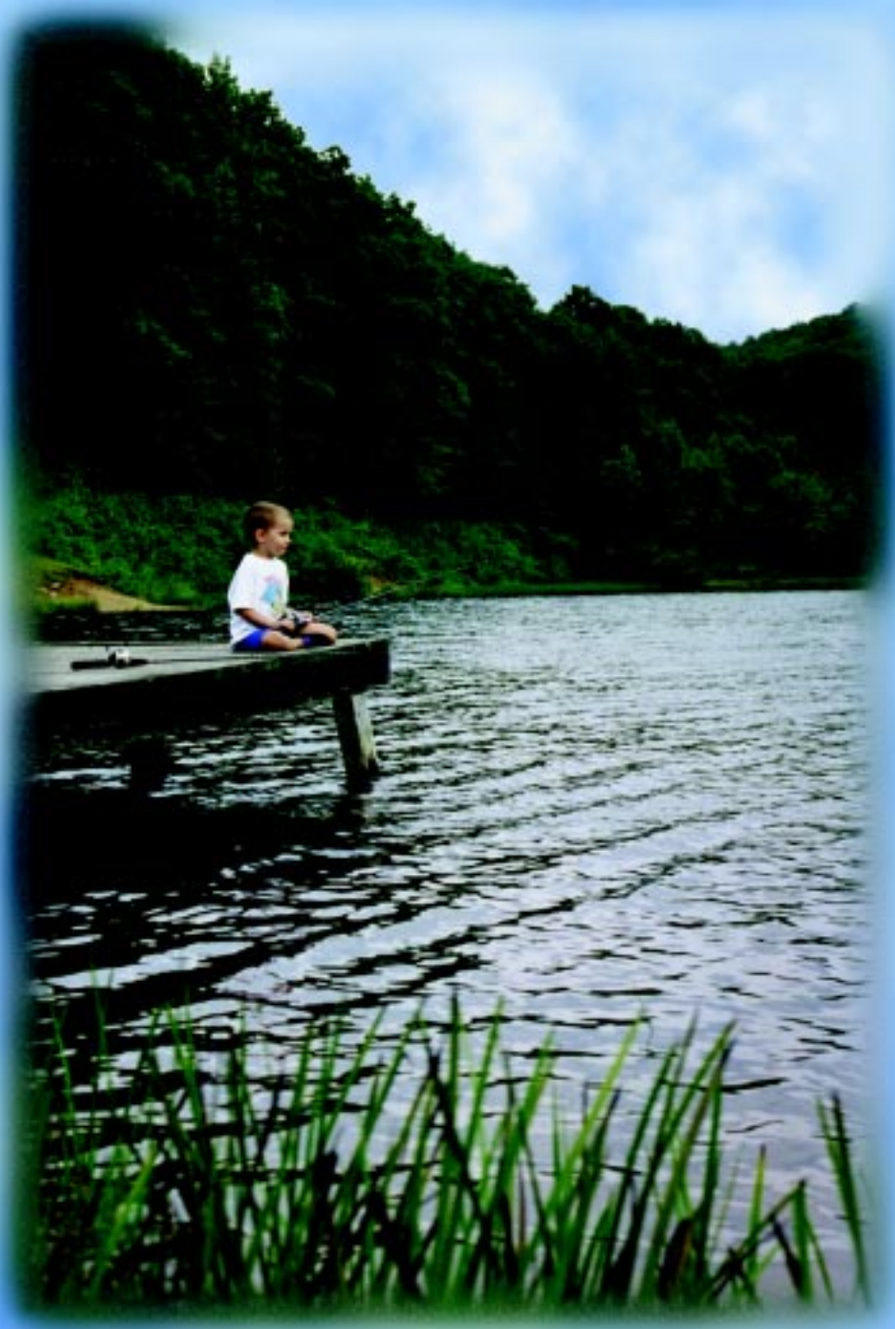
Environmental Solutions



Planning for our future today

FETC

Ecosystem Management: Our Approach to Environmental Solutions

The Federal Energy Technology Center (FETC) develops workable environmental solutions by defining problems within an understanding of the ecosystem. Stated simply, an ecosystem is an interdependent community of organisms and their physical environment. It is like a web, with each part of the community connected to all the others through multiple, interlaced connections. If any part of the ecosystem, living or nonliving, is disturbed, the effects are felt throughout the community.

With this understanding, FETC seeks environmental solutions using an ecosystem management approach. Solutions take into account the entire ecosystem, with the goal of long-term sustainability. This approach is collaborative—industry, academia, private parties, and local, state, tribal, and federal agencies work together as partners—and solutions integrate ecological, socio-economic, and institutional perspectives.

We recognize that other approaches may be used to address some environmental challenges, but we believe that the evolution of our mission and organization, as driven by our stakeholders, is closely aligned with the ecosystem management approach.

SOLUTIONS

SOLUTIONS

SOLUTIONS

The Environmental Solutions of the Future

Clear air, pure water, clean soil—these are desires shared by all. But as our nation's concern for the environment grows, so do its energy needs. The environmental solutions of the future will address both our nation's environmental concerns and its need for energy, in a climate that is cost-conscious and business-friendly. The Federal Energy Technology Center (FETC) is finding these solutions now.

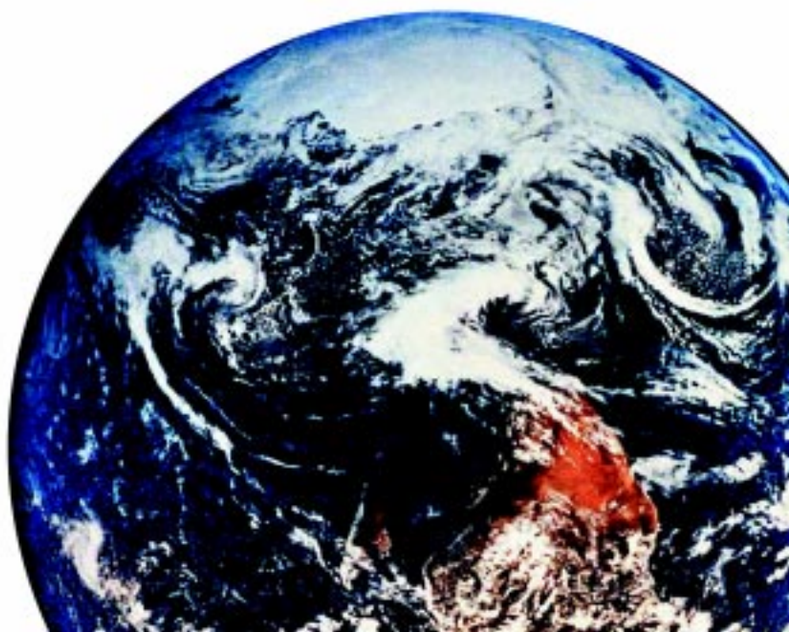
Through FETC's diverse and ambitious research, development, and demonstration programs, and in partnership with our stakeholders, FETC is developing cost-effective technical solutions to environmental problems. Our approach is multi-faceted—solutions address prevention, compliance, and cleanup—and a primary goal is to transfer advanced, environmentally superior technologies to the world.

As one of the largest fossil-energy research organizations in the world, FETC is uniquely suited to address the environmental and energy challenges of the future. We have a long history of integrating ecological and business perspectives in response to our nation's environmental and energy needs. We apply this perspective and experience to new challenges as national and world concerns lead us in new directions, such as global climate change.

We are pleased to present here some of the projects we are undertaking to provide environmental solutions that will benefit our nation now, and for generations to come. Although presented separately, we are mindful that solutions to air, water, and soil problems have wide-ranging, overlapping effects. Entire ecosystems are disturbed by problems in any one of these areas, and entire ecosystems benefit when these problems are solved. Solutions ripple through the entire web of life.

FETC recognizes that today's and tomorrow's energy and environmental problems are not adequately addressed by yesterday's programs, and we are proud to be developing the environmental solutions of the future.

Please take a look . . .



Clear Air

SOLUTIONS

1970

PARTICULATE EMISSIONS

Perspective

Since passage of the 1970 Clean Air Act Amendments, the electric-utility industry has made dramatic strides in reducing air emissions. Particulate emissions, for example, decreased more than 84 percent from 1970 to 1996, even as electricity generation at electric utilities increased by more than 100 percent. By 2010, however, new environmental requirements for coal-based power systems may be imposed to address new and continuing concerns. These concerns include risks to human health, visibility impairment, acidification and eutrophication of ecosystems, and climate change; suspect causes include ambient fine particulates and ozone, hazardous air pollutants, and greenhouse gases.

FETC is working with its government and private sector partners to assess the potential environmental implications of coal-based power production, and to develop cost-effective technologies to further reduce emissions of fine particulates ($PM_{2.5}$), sulfur dioxide (SO_2), nitrogen oxide (NO_x), hazardous air pollutants (HAPs), and carbon dioxide (CO_2). Our history in fossil fuel research provides us with much-needed technological expertise that complements other organizations in the national and worldwide discussions on climate change. These collaborative efforts will help ensure that electric power from domestic coal resources remains an environmentally responsible component of the nation's overall energy mix well into the 21st century.

1996

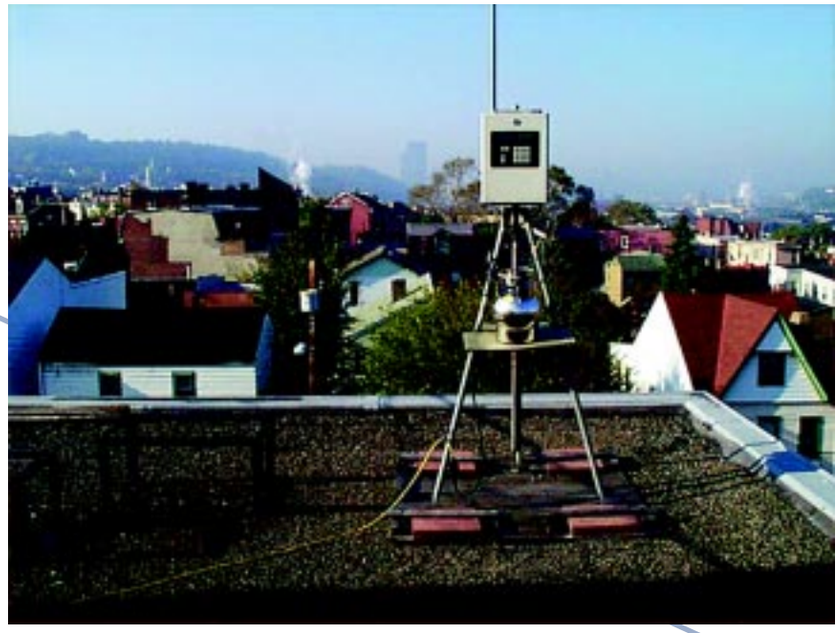
Activities

FETC and its research partners carry out a broad spectrum of research to improve the performance of coal-based power systems, and preserve the quality of the air we breathe. This research includes:

- Developing novel concepts for capturing, sequestering, and reusing greenhouse gases.
- Developing and testing advanced combustion and post-combustion technologies for controlling NO_X.
- Collecting and characterizing ambient fine particulate samples to better identify emission sources, and to develop effective management strategies.
- Developing technology capable of increasing the overall collection efficiency of primary fine particulates.
- Developing technology that can effectively capture all forms of mercury and other air toxics from coal combustion flue gases.

FETC's $PM_{2.5}$ Research Program

FETC is engaged in an ambitious research program to study the scientific and technical issues associated with fine particulate matter, or $PM_{2.5}$. The overall goal of the program is to ensure that sound science and technology are available for any future regulatory decision-making related to the potential health and environmental impacts of ambient $PM_{2.5}$. This program will provide key input to collaborative, nationwide efforts to determine (1) the characteristics of ambient $PM_{2.5}$ in different regions of the United States; (2) spatial and temporal variations in ambient $PM_{2.5}$ concentrations; and (3) the relationship between emission sources, $PM_{2.5}$ composition and concentrations at ambient monitoring sites, and personal exposure. This input will also help determine how a standardized, research-grade ambient particulate matter monitoring network can best be achieved to provide improved air quality data for exposure and epidemiologic studies



Air monitoring devices such as this one in Pittsburgh, PA, help FETC study fine particulate matter.

84% DECREASE

Clear Air

SOLUTIONS

1970

ELECTRICITY GENERATION

Particles in the Air

Particulate matter (PM) is a mixture of solid particles and liquid droplets found in the air. They range in size from particles large enough to be easily seen by the naked eye, such as soot or smoke, to particles that are so small they can only be seen with an electron microscope. Particles with aerodynamic diameters less than 2.5 micrometers are called "fine" particulates, or $PM_{2.5}$. By comparison, the diameter of the human hair is about 80 to 100 micrometers. Fine particulates come from motor vehicle exhaust, power plants, other industries, residential wood stoves and fireplaces, and natural sources such as forest fires. When fine particulates are emitted directly into the air they are called "primary" $PM_{2.5}$; when gaseous precursors undergo chemical reactions in the air to form fine particulates, they are called "secondary" $PM_{2.5}$.

SO_2 NO_x

What are they?

SO_2 is the chemical formula for sulfur dioxide. It belongs to the family of sulfur oxide gases. It forms when sulfur-containing fuel—mainly coal and oil—is burned. NO_X is the symbol for any of the nitrogen oxide gases. These enter the air from high-temperature combustion processes, such as those that occur in motor vehicles and power plants. Both SO_2 and NO_X cause health effects at high concentrations, and together they are the major precursors to acid rain. When SO_2 and NO_X react with ammonia molecules in the air they can also form ammonium sulfates and nitrates, which are types of "secondary" $PM_{2.5}$.

1996

Success in Clean Coal Technology

FETC has a long history of success improving energy efficiency and reducing the environmental impact of coal-fired power generation through implementation of the Clean Coal Technology Program. These successes include the following:

- Cumulative SO_2 scrubber costs have been reduced by over $50 billion and overall SO_2 emissions have been cut by 40 percent since 1970, even though coal use increased 85 percent during this period.
- Low NO_X burners and post-combustion controls to satisfy emissions reduction requirements have been installed in 50 percent of U.S. coal-fired power plants at a small fraction of the cost of previously available technologies.
- Clean atmospheric fluidized bed technology has been commercially deployed with $8 billion in sales.
- More than 600 MW in integrated gasification combined cycle (IGCC) plants have been installed in commercial services with 10 to 20 percent improvement in efficiency, 98 percent reduction in SO_2 emissions, and an 80 percent lower NO_X emission rate than current requirements.
- Three coal-processing plants have been initiated that convert low-rank Western coal and high-sulfur Eastern coal into a product that meets environmental standards.
- New technologies have been demonstrated that improve the environmental performance of steel and cement processes.

FETC's success in clean coal technology has helped improve the efficiency and environmental impact of power plants nationwide.

100% INCREASE

Pure Water

SOLUTIONS

Perspective

The U.S. Environmental Protection Agency (EPA) estimates that at least one third of our nation's rivers, one half of its estuaries, and one half of its lakes are not safe for uses such as swimming and fishing. Microbial contamination, acid mine drainage, industrial discharges, untreated sanitary waste, nonpoint source pollution, and flooding are affecting an ever-increasing number of businesses, residents, visitors, and downstream neighbors. Water quality and quantity problems undermine public confidence in water supplies, constrain industrial and community development, diminish the value of recreational resources, and endanger traditional socio-economic bases. In a recent survey by the Congressional Institute, Inc., Americans identified water pollution as their number one environmental concern.

State and federal agencies charged with monitoring and protecting our water resources have been downsized and fiscally constrained to the extent that significant gaps exist between needs and resources. This decline in water resource management capability has led to an emphasis on data collection to support watershed assessments, watershed priorities, and action strategies, at the expense of actual cleanup. In addition, existing programs only minimally pursue research in watershed prevention, protection, or restoration technologies. The objective of FETC's Watershed Science and Technology Initiative is not only to assess environmental impacts, but to develop and deploy technologies that provide short- and long-term *solutions* to water problems.

The distinctive rust color of acid mine drainage mars the natural beauty of many of our region's streams and rivers.

Activities

FETC is developing technologies for watershed characterization and treatment of acid mine drainage, including:

- Active and passive mine wastewater treatment systems, including bioremediation, phytoremediation, and aeration.
- Geophysical characterization techniques.
- Grouting techniques for stream sealing.

FETC manages the ongoing Mine Waste Technology program for the EPA which includes:

- Remote mine wastewater treatment systems.
- Source control technologies for acid mine drainage from mines and surface waste piles.
- Metal ion removal from acid mine drainage.

FETC plays a key role in developing technologies to address environmental problems associated with hazardous and radioactive contaminants in soil and groundwater throughout the U.S. Department of Energy's weapons complex, including heavy metals and dense nonaqueous phase liquids.

Research under FETC's Watershed Science and Technology Initiative finds solutions to national water quality problems.

Pure Water

SOLUTIONS

The Mountain's Promise Program

By the mid-1990s, hundreds of acres of abandoned surface-mined land scarred the landscape in Preston County, WV, and acid mine drainage had rendered more than two thirds of the county's streams unable to support native fish. In September 1997, FETC was asked by the County Commission to provide advice on a county-wide watershed improvement program. After holding public meetings and reviewing available funding sources, the county submitted an application for an AmeriCorps grant to the WV Commission for National and Community Service. FETC provided technical facilitation and logistical support to bring together some 20 regional governmental, industry, and community organizations in a consortium to design and commit resources to the program. In July 1998, AmeriCorps awarded the county a $147,000 per year renewable grant matched by $35,000 in county funds and $60,000 in partner commitments. Supervised by a full-time program director, 20 AmeriCorps volunteers lead community groups in building wetlands, monitoring and removing litter from streams, planting trees, and raising the community's knowledge of the challenges to their watersheds.

The local newspaper in Preston County, WV, took pride in reporting the launch of the Mountain's Promise Program in 1998, and picturing program participants.

Watersheds and Watershed Partnership

A watershed is a geographical region. Within that region all of the water flows over the land or underground into a common river, river system, or body of water. We focus on entire watersheds to solve water problems because no body of water is isolated. Our landscape is covered with inter-connected waterways—water from streams flows into rivers that flow into lakes or to the sea.

Recognizing that new problems require a new approach to finding solutions, the cornerstone of FETC's activities is its "watershed partnership" approach. Watershed partnership is a cooperative, community-based approach to protecting entire watersheds. Cooperation is key. Watersheds cannot be restored or protected unless all parties—citizen action groups; industry; state, tribal, federal, and local governments; and the general public—work together to identify problems *and implement solutions*.

Our Biggest Source of Water Problems

Nonpoint source pollution results from activities that physically disturb the land or water, such as agriculture, forestry, mining, oil and gas development, grazing, or construction. Urban runoff and improper household management also contribute. In these cases, water from precipitation or irrigation picks up pollutants and deposits them in streams, rivers, lakes, or coastal waters, or introduces them into groundwater. Today this type of pollution is the biggest source of water quality problems in the United States.

Clean Soil

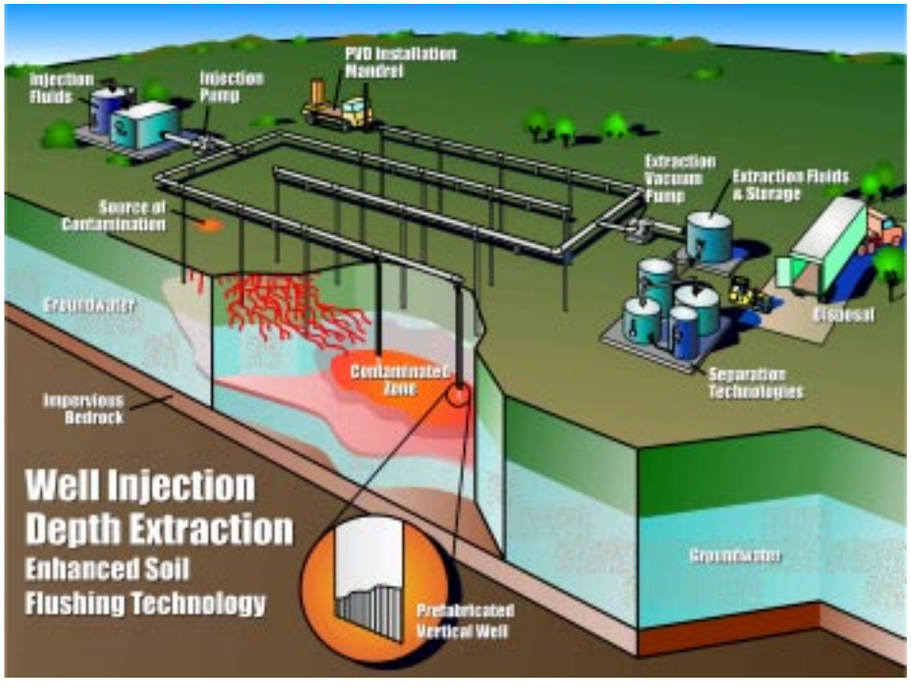
SOLUTIONS

Perspective

Of all the threats to our environment, soil problems may be the easiest to overlook. Unlike the air we breathe, and water, which we drink, we don't use soil directly to sustain us. Our dependence on soil is indirect: we rely on it to grow our crops and lawns, to support forests and other ecosystems, to hold the water we tap into with our wells. Although we depend on it indirectly, clean, productive soil is every bit as vital to our well-being as air and water.

FETC and its research partners are conducting multifaceted research programs to restore and maintain the integrity of our valuable soil resources. These programs range from developing beneficial uses for coal combustion by-products—a pollution prevention approach that generates additional revenues for the utility industry—to treating hazardous and radioactive solid wastes and returning contaminated soil to a productive state. In collaboration with stakeholders, FETC works to minimize the environmental burden from energy production and utilization, and return to public use lands adversely affected by decades of nuclear-weapons production.

Well Injection Depth Extraction using prefabricated vertical wells is one of the technologies FETC is using to clean the soil at contaminated sites



Activities

FETC conducts a variety of efforts in partnership with industry; local, state, and federal governments; and academia to:

- Provide high-quality technical data and information on high-value, high-volume uses of coal combustion by-products.
- Ensure that productive disposition of products from advanced power generation systems is regarded as "common business practice."
- Facilitate the transfer of information and advanced utilization technologies to key stakeholders to promote effective solid waste management.
- Develop and deploy novel and innovative industry-based technologies to address soil contamination.

Making Good Use of Coal Combustion By-Products

U.S. coal-burning electric utilities produce millions of tons of coal combustion by-products (CCBs) each year. Only 25 percent is put to productive use; the remainder ends up in landfills or sluice ponds. Part of the reason that CCBs aren't used productively is that CCBs have traditionally been considered "wastes" by most state agencies; though not hazardous, CCBs are still subject to stringent disposal regulations. Some states have pre-approved some uses of CCBs: fly ash may be used as concrete admixture, for example, and bottom ash as a road base. While this pre-approval streamlines the process, not all states specify pre-approved uses in their regulations, and even among those that do, the allowable uses vary from state to state.

Through its CCB Utilization Research Program, FETC is finding new methods to utilize CCBs so that more "beneficial use" options can be added to the list of pre-approved uses. An exciting aspect of this research is that some of these options solve other environmental problems at the same time. One of the problems being remediated with CCBs is acid mine drainage (AMD), which affects nearly 3,500 miles of streams in Appalachia. CCBs are already used to prevent or remediate AMD at strip mines and coal refuse sites; they may soon be used to remediate the AMD that results from abandoned underground coal mines as well. Many types of CCBs can be engineered to produce grout-like materials with very low permeabilities. FETC has shown that by injecting large volumes of CCB grouts into abandoned underground mines, so that most or all of the void spaces are filled, groundwater can be diverted away from acid-forming materials, resulting in much less damage to the environment.

Soil Contamination

Soil contamination is the presence of pollutants in the soil at concentrations above background levels that pose a potential health or ecological risk. Soils can become contaminated by many human actions including the discharge of solids and liquids at the soil surface; pesticide application; subsurface releases from leaks in buried tanks, pipes, and landfills; and the deposition of atmospheric contaminants such as dusts and particles containing lead. Common soil contaminants include volatile hydrocarbons found in fuels, such as benzene, toluene, ethylene and xylene (BTEX compounds); heavy paraffins and chlorinated organic compounds, such as polychlorinated biphenyl (PCB) and pentachlorophenol (PCP); inorganic compounds, such as lead, arsenic, and mercury; and radionuclides. Often soil is contaminated with a mixture of pollutants. The accumulation, mobility, toxicity, and overall significance of a contaminant depends upon the nature of the soil, the contaminant's chemical and physical characteristics, and environmental factors such as climate and the flow of groundwater through the soil.

SOLUTIONS

Overlapping Problems, Integrated Solutions

Air, water, and soil can be viewed individually for simplicity, but solutions to environmental problems are not simple, and they are not separate. Water evaporates into the air and falls as rain; soil is carried in the air as fine particles; groundwater runs through the soil. Problems overlap, and so do solutions.

Our nation's energy and environmental needs are similarly linked. We cannot solve energy problems at the expense of the environment, nor environmental problems at the expense of an adequate energy supply. Solutions must integrate both needs. FETC—with its successful history of fossil-energy research, and its forward-looking scientists and engineers—is meeting this challenge. FETC's mission is to solve national energy *and* environmental problems.

FETC brings these core competencies to its mission:

- World-class energy expertise and critical expertise in the environmental effects of mining, fuel production, power generation, and related environmental cleanup.
- A suite of strong technical skills including scientific and engineering skills, systems analysis capabilities, and extensive in-house research and development expertise.
- A suite of strong administrative skills including expertise in project management and innovative contracting.
- A proven capability to work effectively and cooperatively with industry, academia, and other government agencies.

From a strong technological base, working together with stakeholders, we are finding solutions to our nation's energy and environmental problems. We are interested in applying our expertise to an even wider range of challenges in the future, and want to continue to build partnerships to ensure a healthy tomorrow. As we build upon our successes, the whole world benefits.

FETC is a field office of DOE's Office of Fossil Energy

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